Vincent F. Neradka, PE, NSWCDD
Thomas R. Konen, NSWCCD
Joseph W. Coleman, NAVSEA

Specification Innovation as a Part of Building an Affordable Fleet

Abstract

The cost of Navy ships is escalating at an unsustainable rate. A surprisingly large part of this escalation is attributable to Standards and Specifications. The Naval Sea Systems Command (NAVSEA) has undertaken several activities to accomplish cost reduction with the goal of building an affordable fleet. One of these, *Documents for Ship Cost Reduction (DSCR),* is the focus of this paper, and it seeks to answer a key question: Without reducing ship capability, can unnecessary costs be driven out of the specifications for building, qualifying, and maintaining our ships? Working closely with industry, NAVSEA has developed an approach to seek out superfluous requirements and to streamline others as two ways to reduce costs. A risk analysis based on the DoD risk methodology has been tailored specifically for the DSCR and incorporated into the process flow, which dramatically reduces the time it takes to implement specification changes. The Navy-industry team has investigated the costliest to comply with "*Top 10*" specifications. These have been investigated using the DSCR process, and the first specification changes have been identified and are being implemented.

Introduction

Norman Augustine, in his book "Augustine's Laws" (Ref. 1), presented the cost of military aircraft as a function of time, and predicted that by the year 2054 such aircraft would be so expensive that the government will be forced to buy one aircraft and share it among the Services. His extrapolations remain generally on target, as can be seen in Figure 1. Navy ships are in no better situation regarding cost escalation as Figure 2 (Ref. 2) shows, and perhaps shipbuilding escalation is even worse because of the lesser economies of scale associated with ship construction. Some cost increase is the consequence of increased complexity and capability of our systems which respond to increasing warfighting needs, and some of it is the result of increased material and labor costs. Somewhat surprising is that specifications and requirements are responsible for cost escalation of a similar order. Figure 3, also taken from Ref. 2, shows that the post-World War II cost escalation for surface combatants (DD-2 through DDG-51 Classes) has averaged

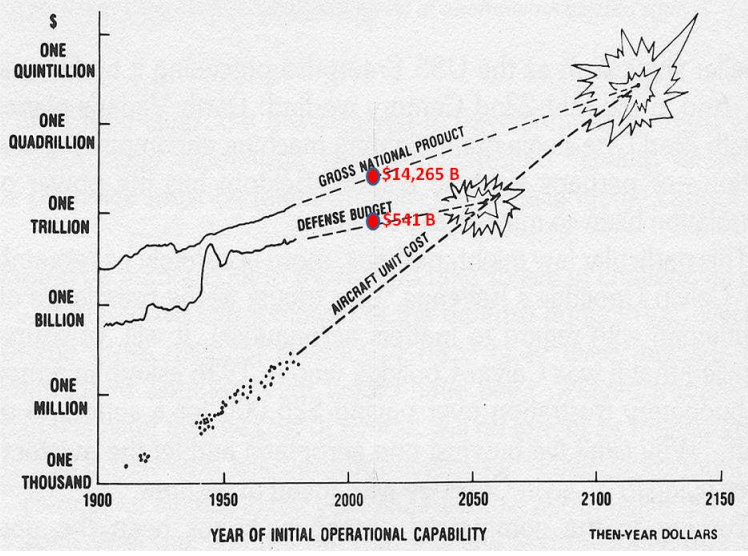

Fig. 1: Cost Escalation of Military Aircraft, Augustine (Ref. 1)

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2010		**00-00-2010 to 00-00-2010**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Specification Innovation as a Part of Building an Affordable Fleet	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Surface Warfare Center, Carderock Division,West Bethesda ,MD**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
ASNE Day-Engineering the Affordable Global Navy Through Innovation Location Arlington, VA, held on April 8-9, 2010

14. ABSTRACT
The cost of Navy ships is escalating at an unsustainable rate. A surprisingly large part of this escalation is attributable to Standards and Specifications. The Naval Sea Systems Command (NAVSEA) has undertaken several activities to accomplish cost reduction with the goal of building an affordable fleet. One of these, Documents for Ship Cost Reduction (DSCR), is the focus of this paper, and it seeks to answer a key question: Without reducing ship capability, can unnecessary costs be driven out of the specifications for building, qualifying, and maintaining our ships? Working closely with industry, NAVSEA has developed an approach to seek out superfluous requirements and to streamline others as two ways to reduce costs. A risk analysis based on the DoD risk methodology has been tailored specifically for the DSCR and incorporated into the process flow, which dramatically reduces the time it takes to implement specification changes. The Navy-industry team has investigated the costliest to comply with ?Top 10? specifications. These have been investigated using the DSCR process and the first specification changes have been identified and are being implemented.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**9**	

9.2% per year. The contribution of specifications and requirements is 2%- nearly identical to the complexity, labor, and equipment categories.

Innovative and effective ways must be found to reduce the cost of ships, particularly during periods of increasing fiscal constraints. In that regard, NAVSEA and industry have undertaken several initiatives to address cost escalation, including: commonality, lean processes, energy reduction, elimination of cumbersome work practices, and ***Documents for Ship Cost Reduction***. DSCR is a NAVSEA initiative focused on the strategic goal to build an affordable fleet by reducing the cost of compliance with specifications and other requirements.

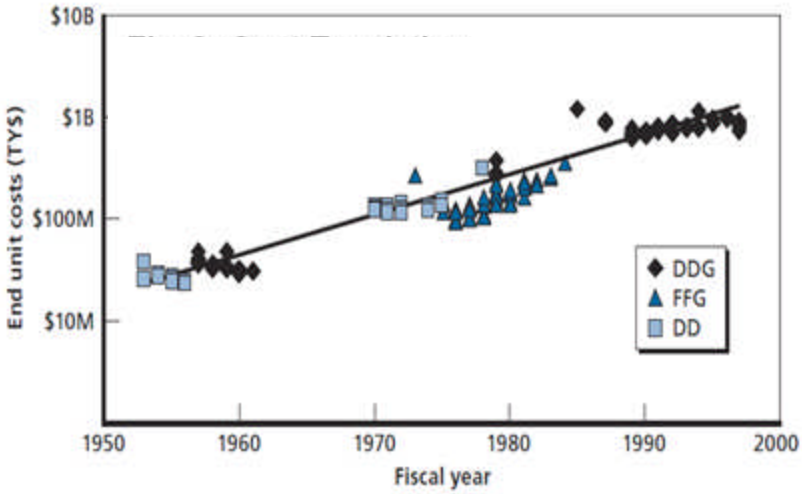

Fig. 2: Cost Escalation of Selected Surface Ships

DSCR attempts to answer the following questions:

Are the specifications used in building and qualifying ships:

- ✓ *relevant, accurate, and up to date,*
- ✓ *interpreted and implemented properly,*
- ✓ *asking for more than is needed- for more than can be afforded,*
- ✓ *"gilding the lily",*
- ✓ *calling for unnecessary testing, and*
- ✓ *making it unnecessarily difficult for contractors to comply with requirements?*

Do contractors have ideas to expedite processes of design, build, and qualify?

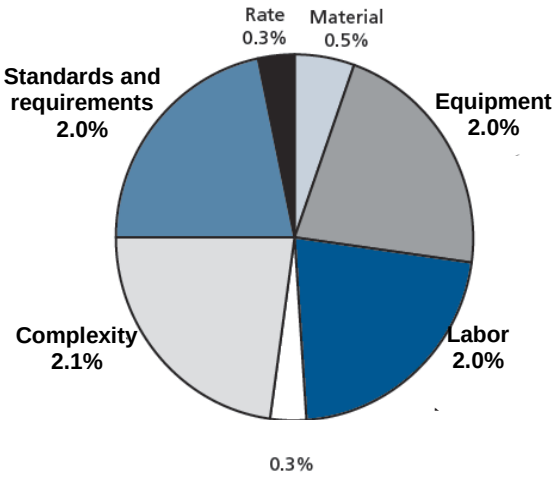

Fig. 3: Contributing Factors to Ship Cost

Answers to these questions, will explicitly address cost implications of existing specifications and standards, and provide changes that will result in more affordable shipbuilding programs, consistent with the NAVSEA strategic plan. In the words of VADM McCoy, *"Find stuff we can no longer afford, or no longer need."*

DSCR Approach

The underlying tenet of DSCR is to not reduce the capability, reliability, and robustness of our systems. Rather, it is to seek out only those requirements that are needed and to eliminate others that are not, thus driving unnecessary costs out of ship specifications. To achieve this, NAVSEA is working in close cooperation with the National Shipbuilding Research Program (NSRP) and the Marine Machinery Association (MMA). Independently, these three organizations each prepared a prioritized list of specifications and requirements that were considered to be the most costly with which to comply. A surprisingly high degree of correlation was observed in the lists. From them, NAVSEA selected the "*Top10*" specifications (Appendix A) to initiate DSCR. The analysis process of DSCR is shown in Figure 4. On a continuous basis, potential cost saving specification changes are solicited from many sources. These are then vetted with NSRP, who provide the industry perspective of the potential for cost savings. Industries may also be visited to solicit additional information. The specification's TWH then evaluates the findings, and performs a risk analysis in general accordance with the DoD policy (but tailored expressly for DSCR). A cost analysis is undertaken, and a specification change candidate having technical suitability and cost benefit is forwarded to the Navy senior review board. This process may involve multiple iterations of the process just described. Upon approval by the senior review board, the Chief Engineer of the Navy (RDML T. Eccles at the time of this writing) issues a letter to NSRP ECB requesting concurrence that the cost candidate when implemented in contract will indeed result in future savings. Upon receipt of concurrence of NSRP, a series of informational briefs are made to industry and within the Navy to foster this implementation.

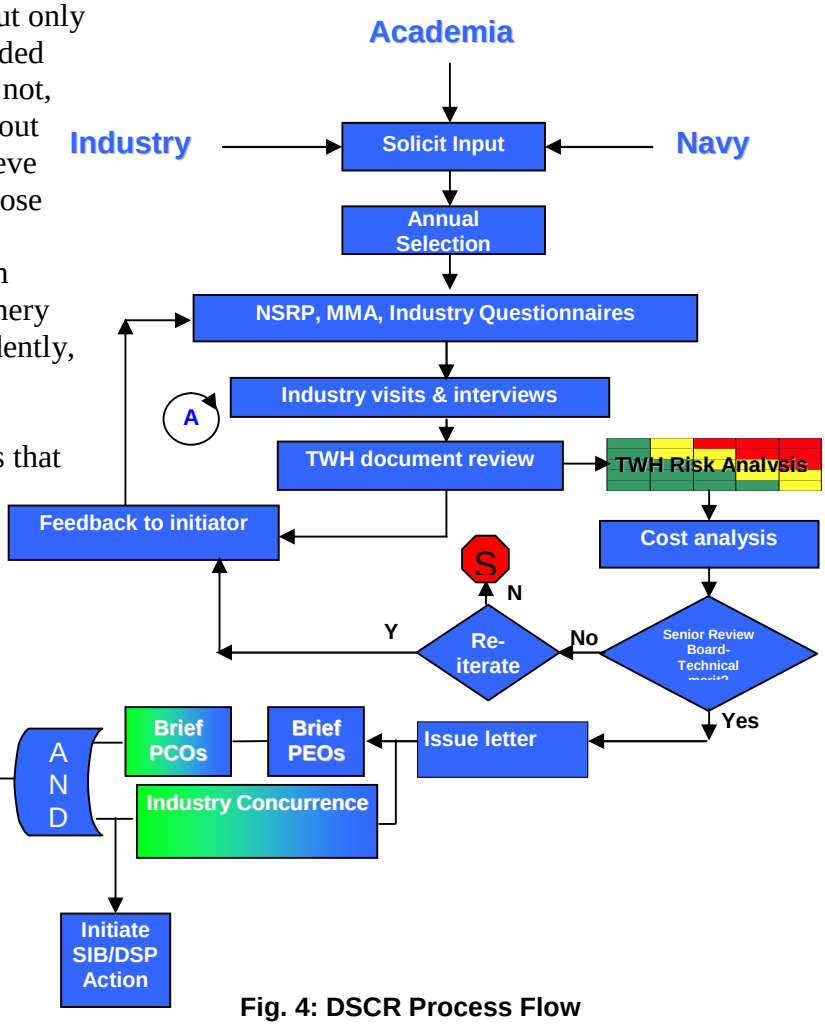

Fig. 4: DSCR Process Flow

NAVSEA's Technical Warrant Holders (TWH) visited over 30 factories and shipyards to "walk the floor" where the specifications and requirements are being implemented. The Technical Warrant Holders are recognized experts in their field who formalize NAVSEA's

technical position on all issues pertaining to Hull, Mechanical and Electrical (HM&E) equipment and Weapons Systems. The TWHs evaluate cost saving specification changes, and submit them to stakeholders in the ship design groups in NAVSEA. The NAVSEA TWHs responsible for the specifications also evaluate recommendations for cutting costs, perform formal risk analyses and carry out qualitative cost analyses.

Key to the success of DSCR is the close NAVSEA-industry cooperation and rapid response. Numerous meetings helped facilitate the process, and they continue. NAVSEA and industry representatives are also often working on the same technical committees to hammer out potential cost-saving changes to specifications. The industry input and concurrence with the recommendations is essential to the process.

Risk Analyses

As differences of opinion are resolved through loop "A" of Figure 4, the document enters the risk analysis phase. Risk analysis is performed by tailoring the well-known methodology of DoD (Ref. 3). In short, the risk of making a particular change to the specification is identified in the context of the probability of a problem occurring and the severity of that problem, should it occur. These two risk components are ranked from 1 (minimal/no risk) to 5 (high risk). By treating all the potential specification changes in this way, there is a consistent approach to balancing the risk and reward (cost savings), and to communicate this to management for adjudication. A Risk Reporting Matrix of *consequence* of occurrence and *probability* of the occurrence for one specification's proposed changes is shown in Figure 5.

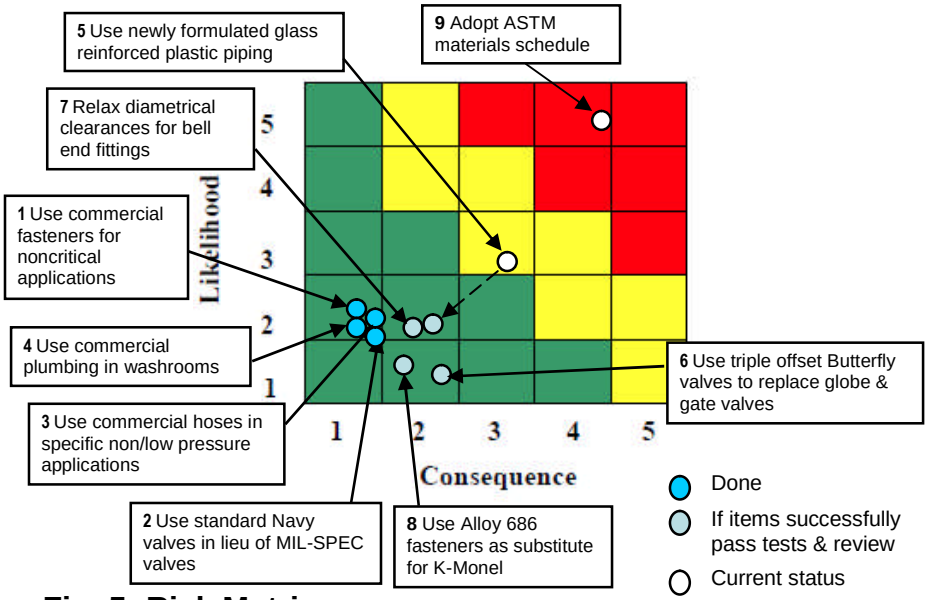

Fig. 5: Risk Matrix

The NAVSEA team performs cost analyses where the risks are acceptable. Initially, the emphasis is not on quantifying the precise cost, but rather providing assurance that the cost savings are worth the expense of revising the specification. Where the cost saving is sufficient, the recommended changes will be promptly offered to industry.

The NSRP has established working groups and an internal process to review cost savings recommendations. This also allows them to request contract changes to implement the cost

reductions at their first opportunity. This stage of the process is initiated via a letter from the Chief Engineer of the Navy, in 2009 RDML Thomas J. Eccles. With industry concurrence, the cost savings recommendations will be referred to NAVSEA's Ship Design Managers and Program Executive Offices (PEOs) for inclusion into Ship Specifications and appropriate acquisition documents (MIL SPECs, Naval Vessel Rules (NVR), and contracts).

Initial Specification Change Recommendations

Although the DSCR process continues to evolve as this is written, some promising early results have been identified. The DSCR has developed a methodology that can be applied to specifications beyond those in the *Top 10*, expanding the scope of the initiative to further reduce costs. Through the fall of 2009, five letters forwarding cost-savings recommendations have been submitted to the NSRP for evaluation. The following are the initial changes:

Motors (Ref. 4)

The military specification for motors, MIL-DTL-17060G (SH) 08-JAN-2009 Motors, Alternating Current, Integral-Horsepower, Shipboard Use, has now been released. This specification covers the requirements for three-phase, alternating current (AC) motors for shipboard use. This revision incorporated 783 changes and clarifications to the previous revision. The major motor changes include:

1) *Use of Sealed Insulation Systems for motors only where military requirements for criticality and environment require it*. The cost savings result from use of less expensive motors and less costly motor repair.
2) *Use of brushless motors.* Cost savings are primarily derived from the elimination of maintenance associated with brush cleaning.

   See Figure 6, from Ref. 5, which shows commutators that indicate brushes in need of replacement.

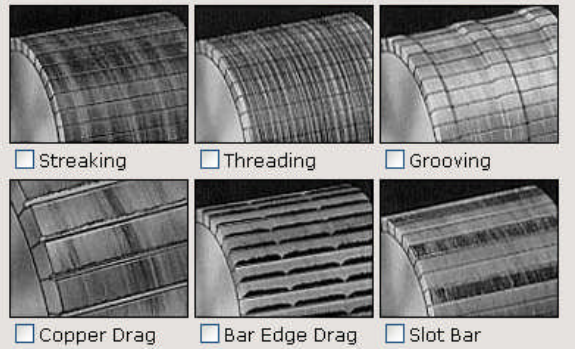

Fig. 6: Commutators Indicating Brushes in Need of Replacement

3) Updated requirements for variable speed drives and permanent magnet motors.
4) *Updated sealed bearing applications.* Costly sealed bearings are now only required where criticality and environment dictate.
5) *Removal of unique coating and casting requirements, and replacement of them with American Society for Testing & Materials (ASTM) standards.* Costs are reduced at the manufacturer because assembly lines for military motors will share the same coating and casting requirements as similar commercially similar motors.

Welding (Ref. 6)

The first cost reducing changes to the welding documentation are being incorporated in the Naval Vessel Rules (NVR), Part 8. These were published in March 2010. These changes include:

1) *Allow hydrostatic testing of coated piping weld joints.* The previous requirement was that all pipe welds had to be uncoated for hydro testing. It was costly to mask, and then manually paint. This process was deemed unnecessary, and the requirement has been deleted, saving a considerable number of man-hours.
2) *Allow standard welding procedures/approved shipyard procedures for vendors, eliminating individual procedure qualification.* Each activity was previously required to qualify its own welding procedures. For common materials and processes, it is considered appropriate to permit use of pre-qualified or shipyard-approved procedures in lieu of independent qualification.

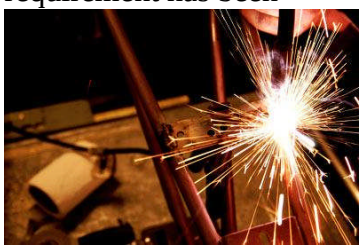

Fig. 7: Welding

3) *Replace workmanship (not quality) recordkeeping requirements for non-critical applications.* It was felt that workmanship recordkeeping costs could be reduced, but quality recordkeeping continues to be considered essential.
4) *Do not require welding electrode diffusible hydrogen testing at the shipbuilder*. Relying on supplier testing eliminates the need for the individual shipyards to buy expensive equipment and train their staff to perform what is a redundant test.
5) *Expand waiver of weld procedure qualification to include non-critical dissimilar metal welds, eliminating the need for additional qualification of procedures.* The previous qualification waiver was limited to only the same structural materials metals group, so non-critical dissimilar welds still required advance Navy approval. The change was to expand qualification requirements to include non-critical dissimilar metal welds**.**

Items 2 through 5, are currently in the American Bureau of Shipping Naval Vessel Rules (ABS NVR) annual revision process (industry review), to be published in January 2010.

Piping (Ref. 7)

The changes to the piping specification, MIL-STD-777, are in the Government-Industry review process, and a revised specification is anticipated FY10. These changes include:

1) *The use of commercial fasteners, specified in top-tier documents in lieu of fasteners meeting military specifications*. This has an impact not only on the cost of these items, but also on the cost associated with inventory and installation.

Fig. 8: Use of Flexible Hose

2) *Inclusion of Belled End Fittings.* The use of these fittings will facilitate installation.
3) *Expansion of the use of Standard Navy Valves, where system design pressures and temperatures do not exceed valve material and design limits.* The greatest benefit of this change is lower installation cost.
4) *The use of commercial flexible hoses to SAE J20 S6430-AE-TED-010, Volume l, for connecting non-pressurized condensate gravity drains from cooling units to drain piping*. The use of flexible hoses will greatly simplify installation.
5) *Use of commercial plumbing fittings, excluding PVC, in supply piping downstream of a space cutout valve in washrooms, and for plumbing applications in spaces serviced by deck drains.* The use of these commercial fittings makes use of less costly hardware, reduces installation time, and increases competition (because there are a limited number of valve manufacturers who are willing to maintain Navy standard product lines).

Shock (Ref. 8)

Shock integrity is verified by compliance with MIL-S-901. Changes to this specification are in process, and some of the expected changes include:

1) One means to reduce the cost of shipboard equipment is to reduce the shock grade requirement. In many cases a change of the high intensity shock requirement from Grade A to Grade B may be acceptable and achieve significant savings in design and testing. Another recommended change is in shock testing methodology,
2) Permit the use of a new Deck Simulating Shock Machine (DSSM) that will reduce the cost of testing as compared to the legacy Floating Shock Platform (FSP),
3) Reduce the number of blows in a FSP or hammer shock test,
4) Permit vendor self certification,
5) Use of Open Physical Architecture for electronic cabinets.

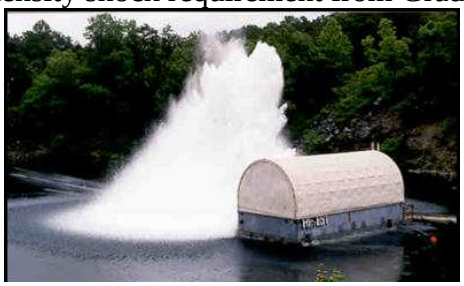

Fig. 9: Floating Shock Platform Test

Electromagnetic Interference (EMI) (Ref. 9)

The cost savings methodology of EMI differs from the approach taken by the other DSCR projects. The EMI standards were found to be technically acceptable to reviewers in industry and the other services. However, unnecessary expense related to EMI testing and approval arises as a consequence of inconsistencies and inefficiencies in understanding the EMI evaluation process (Ref. 10). To address the, in many cases unnecessary, expense of over testing due to the lack of familiarity of these standards, the TWH has recommended the development of two tools: a Best Practices Guide and an EMI Software Tool.

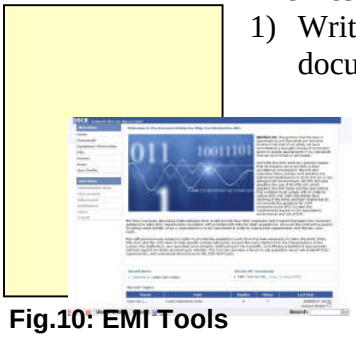

Fig.10: EMI Tools

The Best Practices Guide is a guidance document that includes chapters on:

1) Writing good EMI performance requirements for acquisition documentation and contracts (including guidance on tailoring),
2) Navy Electromagnetic Environmental Effects (E3) chain of command, and points of contact for different classes of equipment,
3) EMI test procedure writing,
4) EMI test report writing,
5) Request for Deviation, Waiver and Extension writing, and
6) Discussion of the Navy's risk assessment process and principles.

The Best Practices Guide will benefit NAVSEA's Life Cycle Managers (LCMs), In Service Engineering Agents (ISEAs), and Program Managers in writing EMI test requirements into their specifications and risk management plans. Shipbuilders and vendors will benefit by having a clear approach to testing with unambiguous test plans. EMI test labs will benefit from concrete examples of how to write EMI Test Plans (TPs) and EMI Test Reports (TRs) that meet Data Item Descriptions (DID) requirements that provide the necessary details to enable the test plans and EMI test reports to pass on the initial submission. The Best Practices guide was released in 2009.

The companion to the Best Practices guide is the EMI Software Tool. The software tool was created in order to provide the acquisition work force the tools necessary to tailor the limits of MIL-STD-461F and MIL-STD-464A to their specific system, taking into account the many factors from the characteristics of the system, the platform(s), and the operational environments, addressing E3 risk tradeoffs and offering submittal of requirements and test reports for faster processing by NAVSEA. This tool also provides a forum to ask questions about risk tradeoff of E3 requirements and commercial alternatives to MIL-STD-461F tests. The beta version of the on-line software tool was scheduled for release in early 2010.

Conclusions

During the execution of the first year of DSCR, the NAVSEA-industry team developed an iterative process has been developed to proceed from solicitation of suggested recommendations through working with PEOs and Program Contracting Officers (PEOs/PCOs), Supervisor of Shipbuilding, Construction & Repair (SUPSHIP), shipbuilders, and industry that should result in Total Ownership Cost (TOC) reductions. "Should" is emphasized because savings will not be realized until changes are implemented in contracts, as illustrated in the process flow chart, Figure 4. Within this architecture, DSCR has developed a methodology that can be applied to specifications other than the *Top 10*, expanding the scope of the initiative, which can further reduce costs. The team has developed a consistent risk analysis methodology tailored to the DSCR. The Risk Reporting Matrix of consequence of occurrence and probability of the occurrence has been employed by each TWH in assessing risk of potential changes to specifications. This methodology provides a uniform basis for evaluating risk and also provides an archival record of the decision process.

Industry has been highly responsive to participating in the DSCR initiative. In fact, their participation has been crucial to the process. Working together, it is clear that specification revisions, if innovatively undertaken, can reduce the cost of ship acquisition and TOC. While some of the cost savings come from reducing requirements, others are attributable to application of new technology and more precise implementation of the specification writer's intentions. The methodology of the DSCR also has the advantage of getting more immediate cost savings by allowing sensible changes to be implemented well in advance of the formal specification revision.

As the first year of the initiative comes to a close, and the beginning of close-out of some of the *Top 10* is in sight, additional specifications are under consideration for acceptance into the DSCR process. Cost reductions are only now beginning to be quantified, and there is every expectation that they can be significant in reducing the Total Ownership Cost of our ships through both acquisition and life cycle cost reductions. Specifications contribute 2% of the 9.2% cost escalation, and DSCR is one way to reduce this element of cost, helping to make the goal of a "313 Ship Navy" become a reality.

References

1. Augustine, Norman, *Augustine's Laws*, New York, Viking Penguin, 1986.
2. Arena, M.V., et al., *Why Has the Cost of Navy Ships Risen?*, RAND National Defense Research Institute, Santa Monica, CA, 2006.
3. Risk Management Guide for DoD Acquisition, 6th Ed., 2006.
4. MIL-DTL-17060G Motors, 60 Cycle, Alternating Current, Integral HP, Shipboard Use.
5. Helwig Carbon, Inc. http://www.helwigcarbon.com/technical/troubleshooting.aspx
6. NVR Rules Part 8.
7. MIL-STD-777 Schedule of Piping, Valves, Fittings and Associated Piping Components for Naval Surface Ships.
8. MIL-S-901D Shock Tests, H.I. (High Impact) Shipboard Machinery, Equipment, and Systems, Requirements for.
9. MIL-STD 464A Electromagnetic Environmental Effects (E3) Requirements for Systems.
10. Email from James Kidd to Don Pierce, et al, dated 21 Oct. 2009.

Appendix A- "Top 10" and Associated TWH

- MIL-STD-777 Schedule of Piping, Valves, Fittings and Associated Piping Components for Naval Surface Ships. *TWH - Michael Felde SEA 05Z41*
- Naval Vessel Rules Part 8 relative to MIL-STD-1689 and MIL-STD-278 Fabrication Welding and Inspection of Ships Structure. *TWH - Gene Mitchell SEA 05P24*
- MIL-DTL-17060 Motors, 60 Cycle, Alternating Current, Integral HP, Shipboard Use *TWH - Khosrow Moniri SEA 05Z32*
- MIL-DTL-16036 Switchgear, Power, Low Voltage, Naval Shipboard in conjunction with use of MIL-Spec circuit breakers (MIL-C-17587, MIL-C-17361). *TWH - Khosrow Moniri SEA 05Z32*
- MIL-STD 167 Mechanical Vibrations of Shipboard Equipment) and
- MIL-STD-740 Airborne and Structure Borne Noise TWH - *Richard Taddeo SEA 05P12*
- MIL-STD-461E Electromagnetic Interference (EMI),
- MIL-STD 464A Electromagnetic Environmental Effects (E3) Requirements for Systems
- MIL-STD-469B / National Telecommunications Information Administration (NTIA), and Chapter 5 Radar Engineering Interface Requirements, Electromagnetic Compatibility – Frequency Spectrum Guide for Radar. *TWH - Mark Johnson SEA 05H3*
- MIL-S-901G Shock Tests, H.I. (High Impact) Shipboard Machinery, Equipment, and Systems, Requirements for. *TWH - Michael Winnette SEA 05P13*

Acknowledgement

The authors would like to acknowledge the support of the many people who contributed to this effort: John E. Bibel, David A. Breslin, Roger B. Carr, Michael, J. Campbell, John J. Carvil, Keith Cook, Leonard K. Dowgewicz, Michael S. Felde, Gene L. Franke, Terry T. Gundersen, Joseph G. Hungerbuhler, David M. Johnson, Keith J. Lannan, Michael J. Martin, Gene E. Mitchell, Khosrow H. Moniri, James D. Pierce, Clinton E. Randolph, George Rasich, Robert W. Rubega, Richard F. Taddeo, Elvin D. Thomas, Michael A. Till, Domenic A. Urzillo, Richard J. Wiersteiner, and Michael C. Winnette. Without their help and patience, and the assistance of those in industry too numerous to list, this initiative would be impossible.